PHASE 1 / REVISED JURY PROJECT PLAN

# TITANIC Micro AUV Simulation Project Plan

*Unreal Engine 5 mission simulator and educational video game*

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Project title as posted
TITANIC Micro-AUV: Autonomous Robotic Exploration and Non-Contact Mapping of Confined Deep-Sea Wreck Interiors

TeraOpenScience public project post 11758

Robotics and simulation • Revised November 7, 2026 • Defense target April 23, 2027

## 0 Project Summary

I propose an Unreal Engine 5 simulator to investigate how a compact autonomous underwater vehicle could document a wreck without touching it and return when visibility, communications or navigation degrade. The same simulation will support a standalone Windows educational game for the public, built around planning a survey, supervising the virtual vehicle and reviewing its decisions. By April 23, 2027, I aim to deliver a playable offline build, a research scenario suite, reproducible results and a requirements dossier for a possible future vehicle. All work in this proposal is digital, with published hardware specifications and robotics interfaces used to ground the models.

## 1 Innovation

### What is new

The project links a return-aware AUV simulation to a playable public mission. Research mode exposes clearance, pose uncertainty, energy and actuator limits. The public game turns those same constraints into decisions the player can make and review.

### Closest alternatives

BYU HoloOcean provides Unreal-based marine robotics sensing and autonomy experiments. MarineGym and GRAAL Lab provide NVIDIA-based underwater research examples. This project contributes a Titanic-inspired educational mission with a shared model, test protocol and post-mission evidence review. [1, 10–11, 17–18]

### Expected improvement and original contribution

Test whether the return-aware supervisor reduces contacts and failed recoveries versus a matched waypoint baseline. Target a 20 percentage point improvement from pre- to post-play on a short knowledge check. My original contribution is the compact AUV concept and its integration with a mission design that makes engineering and conservation tradeoffs visible. [1]

# 2 Technical Plan

## Build approach and tools

Use Unreal Engine 5, built-in Chaos rigid-body/contact physics, a project-owned C++ marine dynamics plugin, and Blueprints for presentation and mission scripting. Start with a simple corridor and an exterior survey scene based on the article's concept geometry and legally cleared assets. Keep a shared dynamics and sensor configuration across the research harness and the public build. Compare HoloOcean and published Fossen equations as references. Use NVIDIA tools only for bounded research comparisons if resources allow. [1, 3–5, 10–18]

## Biggest unknowns and how they will be resolved

Verify water-force signs, units and fixed-step timing before adding autonomy. Compare steady-state and transient responses with independent numerical cases and sweep uncertain hydrodynamic and sensor parameters. Verify packaging early, budget the sonar and rendering updates, and test whether players understand why the supervisor turns back.

## Test and iteration sequence

Unit tests → dry software integration → empty-water scene → overhead wreck analog → fault campaigns → clean-machine packaged build and user testing. Record each run's seed, scenario, configuration, engine version, truth, observations and decisions. Preserve discrepancies and failed runs.

| April decision metric | Provisional target for the digital demonstrator |
|---|---|
| Dynamics and repeatability | Analytical cases within 5% for tested nonzero steady-state quantities, with explicit absolute tolerances near zero. Seeded repeats match event order and published numerical tolerances on the reference build. |
| Survey and return | At least 9 of 10 nominal scenario runs map and return. All scored nominal runs maintain ≥0.15 m geometric clearance and zero contacts. Target ≥80% target coverage and ≤0.10 m registered map RMSE. |
| Fault and safety response | At least 18 of 20 fault runs reach the expected return or designated safe-hold/abort state without operator intervention. Any contact is a safety-test failure. Report cases with no viable recovery route. |
| Game and learning | Offline Windows build completes the tutorial and mission on two test PCs. On a named 1080p test PC, target a 95th-percentile frame time ≤33.3 ms. Seek ≥20 percentage point mean paired learning gain among at least 10 consenting adult testers. |

These are simulated acceptance targets. Baselines, denominators and final scoring limits will be frozen before scoring. See Appendices A–H.

# 3 Execution Plan

## 3.1 Milestones

| Period | Milestone | Done when |
|---|---|---|
| Nov 16–Dec 15, 2026 | Freeze scope and toolchain | Pin a supported UE5 minor version after Windows packaging smoke test. Approve core model, asset rights register, budget and feature list. |
| Dec 16–Jan 15, 2027 | Pass dynamics tests | Marine model, virtual thruster map and SI/frame adapter pass core tests. Export first repeatable logs. Submit two-month report on organizer schedule. |
| Jan 16–Feb 15 | Complete first playable loop | Finish tutorial, exterior survey and a single fictional overhead scenario. Demonstrate sensor degradation and clear-water return. |
| Feb 16–Mar 15 | Freeze game and test protocol | Complete fault injection, debrief and accessibility pass. Pilot the paired learning test. Submit four-month report on organizer schedule. |
| Mar 16–Apr 23 | Deliver and defend | Package offline build, score engineering and learning trials, complete license checks and prepare store/demo materials. Defense window Apr 19–23. |

## 3.2 Business Outline

| Prompt | Proposed answer |
|---|---|
| Target customer | PC simulation players, maritime history audiences and educators who want an accessible marine robotics demonstration. |
| Value | One playable mission illustrates why clearance, energy, sonar, communications and conservation constrain an underwater survey. A debrief explains each abort and the evidence behind it. |
| Rough economics | Test an indicative $14.99 retail price. At 65% assumed net receipts, about 637 copies recover the $6,200 cash plan, before any ongoing support and contributed labor. This is a scenario, with store terms and demand to be verified. |
| Path to market | Use a playable demo, educator and museum outreach, and store-page interest to test demand. Plan a separate paid Windows release after acceptance and rights review. [8–9] |

## Resources and cash control

Total development cash budget is $6,200 including $1,000 contingency, leaving $800 below the $7,000 threshold. The baseline assumes contributed applicant time. Spending stays below $7,000 through scope cuts and written change control. The build assumes one primary desktop platform and offline single-player. See Appendix E.

# 4 Capacity to Deliver

## Background

I hold BS and MS degrees in electrical engineering from Wright State University and am a PhD student in Electrical and Systems Engineering at the University of Dayton. I authored the micro-AUV concept article and co-authored Intelligent Autonomous Drones by Cognitive Deep Learning. My relevant work includes simulation, autonomy, ROS 2, embedded systems and controls. [1]

| Skill area | Who covers it | Role |
|---|---|---|
| Engineering | Applicant | Requirements, C++ marine model, control allocation, software interfaces and technical documentation. |
| Testing and data | Applicant and reviewers to be arranged | Verify dynamics and telemetry, run regression and usability tests, and review model limitations. |
| Business and customers | Applicant | Interview educators and players, test pricing, and prepare release materials and support scope. |
| Other | Prospective UE, education and heritage reviewers | Time-boxed review of packaging, accessibility, lesson accuracy and historical interpretation. |

Planning estimate is 8–10 applicant hours per week, approximately 180–230 hours across the schedule. Availability, workstation access, advisor participation and institutional support remain to be confirmed.

# 5 Real World Impact

The public can explore why a real wreck survey depends on preservation, engineering and recovery planning. The research harness gives students and engineers a repeatable way to see where localization, propulsion, visibility, communications and energy assumptions fail. The resulting traceability dossier identifies measurements and approvals a future vehicle program would need. [1, 19–23]

Potential beneficiaries include educators, museum audiences, robotics teams and heritage specialists. The game can also introduce non-contact mapping and the uncertainty of comparing repeat surveys. Titanic is treated as a maritime memorial. Public gameplay begins with an exterior survey and labels the overhead training corridor as fictional. [23]

# 6 Confirmation

“All work will follow applicable university, platform, consumer-safety, consent, and privacy requirements.”

Applicant name • David Allen Blubaugh
Confirmation date • _____ (applicant to enter upon confirmation)

The supplied Phase 1 template lists November 6, 2026, at 11:59 p.m. ET as its deadline. The revised plan keeps the template’s April defense window.

# A Game and Research Design

## One simulation with two ways to use it

Research mode accepts versioned mission, vehicle, sensor and fault configurations through a local harness. It supports seeded batch runs, repeatable reset, state export and side-by-side runs of the waypoint and return-aware controllers. Ground truth is available to the scorer and debug overlay. Controllers receive modeled sensor data.

Public mode is a separate paid Windows product built from the shared UE5 project. A short tutorial teaches sonar, visibility and energy, followed by a Titanic-inspired exterior survey and a clearly fictional overhead training scenario. The player chooses a route and relay location, deploys a virtual vehicle, inspects the sonar or camera, and decides whether to continue or return. An after-action timeline explains outcomes with a map, confidence shading, minimum clearance, return reserve and abort reasons.

| Mission step | Player or researcher decision | Simulation evidence |
|---|---|---|
| Plan | Select targets, no-entry boundaries, speed and relay waypoint. | Versioned route, sensor presets and allowable envelope. |
| Survey | Use sonar when visibility falls. Compare alternatives without touching surfaces. | Time-stamped observations, map uncertainty and contact checks. |
| Decide | Inspect the estimated way home and remaining energy. Continue only within the modeled limits. | Supervisor decision, predicted return energy and cleared route. |
| Respond | Try a verified retreat on a drop-out or fault. Use the modeled recovery procedure if retreat is infeasible. | Injected event, state transition, route outcome and ground truth. |
| Debrief | Explain why an apparently accessible path might be unsafe. | Annotated replay, knowledge check and limitations. |

## Public release scope

The first release target is offline single-player with keyboard and mouse, scalable display settings, remappable controls where supported, readable sonar legends and captions. Keep one AUV, one tutorial and two small mission scenes. Export local logs only when explicitly requested. Collect research-test responses separately with consent and applicable institutional review. Reserve multiplayer, VR, large open worlds, extra vehicles and expanded campaigns for later consideration.

Use a fictional corridor with surveyed synthetic geometry for testing. Historical bow geometry, imagery or photos require provenance and asset rights review. Documentation covers preservation, non-contact sensing and survey uncertainty. Artifact acquisition and graphic depictions of human remains are outside the gameplay scope. [1, 23]

# B Physics and Plugin Architecture

| Component | Role and release decision |
|---|---|
| Chaos and physics substepping | Required UE5 core for rigid-body integration and contact. Start with a 120 Hz physics target and 20 Hz controller, driven from simulation time. Measure real packaged step behavior and log missed-step conditions. [3–4] |
| Project marine dynamics plugin | Required project-owned C++ module for submerged forces, thrusters, current and modeled sensors. Keep marine coefficients separate from level design. Use engine-independent unit tests and an explicit adapter at the UE boundary. |
| Water plugin and presentation | Optional Water plugin for surface staging only. Use underwater post-processing and Niagara for presentation as needed. Keep cosmetic turbidity and particles separate from sensor degradation and scoring. [5–6] |
| Enhanced Input and packaging | Use Enhanced Input for controls and Epic's Windows packaging workflow. Test a Shipping build with optional tools and editor dependencies removed. [7–8] |
| External tools | HoloOcean and Stonefish are reference or comparison environments. Isaac Sim and Isaac Lab are research options. Keep all four outside the packaged game dependency chain. [10–18, 22] |

## Six degree of freedom model

Start with a Fossen-style rigid body and current-relative water loads. Include weight and buoyancy applied at separate centers, added mass, linear and quadratic damping, and per-thruster force and moment. Start with diagonal coefficients, then add couplings only when sensitivity results justify them. Use a 0.508 m target for the full guarded vehicle envelope, based on the article's concept, and track the assumptions behind volume, mass, inertia and trim. Model pressure and structural survival separately as scenario inputs. [1, 10–11]

Let Chaos integrate rigid-body inertia and gravity. Apply the marine wrench once per physics step. Represent added mass with a documented coupled acceleration solve or an equivalent correction, with tests against an independent reference and explicit treatment of contact. Avoid duplicate buoyancy or damping from engine settings. Convert SI units and coordinate handedness at the engine boundary, including torque and angular velocity conventions.

## Thruster geometry and tests

Screen the eight-thruster candidate with four vectored horizontal and four reversible vertical units. Each column of the allocation matrix pairs a force direction with its moment about the center of mass. Test scaled singular values, achieved wrench, coupling, saturation and every single-unit outage. Use bounded allocation with asymmetrical thrust, lag, deadband, current and slew limits. Verify free drift, neutral buoyancy, displaced-center righting, fixed-command acceleration, terminal speed, thrust signs and collision logging. [1, 19]

# C Hardware Traceability

Hardware references constrain parameter ranges and interface definitions for the simulated AUV. Maintain a ledger with part family, source, rating, assumed value or range, model version and confidence. Future measured data can replace an assumption without redesigning the game. Example products are reference classes and do not imply deep-sea suitability or procurement.

| Real robotics element | Simulation representation | Future evidence needed |
|---|---|---|
| Spherical enclosure, guards, penetrators and ballast | CAD envelope and contact hull. Mass, center of gravity, center of buoyancy, displacement and design-depth metadata. | As-built tolerances, pressure test plan, seal and material qualification, trim and stability. |
| Thrusters and ESCs [19] | Eight virtual channels. Parameter tables for force vs command, current vs load, reverse thrust, lag and fault state. | Representative thrust tests, wash interaction, endurance, bus protection and saturation. |
| Imaging sonar, camera and lights [20] | Ray- or beam-sampled sonar with range and update limits, noise and configurable false returns. Camera attenuation and scatter, lighting and occlusion. | Measured beam/range characteristics, calibration and validation across turbidity and metallic geometry. |
| IMU, depth sensor and optional DVL [21] | Noise, bias, drift, sample time and dropouts. DVL beam geometry and bottom-lock loss where relevant. | Reference data, timing, mounting, depth calibration and confined-space observability. |
| Optical and acoustic modem with relay [1, 24] | Line-of-sight link budget surrogate, range and alignment, latency, bandwidth and packet loss. Acoustic multipath cases and low-rate command/status. | Measured link performance, relay siting and a verified failure-handling plan. |
| Battery, embedded compute and watchdog [16] | Virtual power budget, energy reserve, processing delay and watchdog behavior. Jetson and Pi candidate profiles record assumptions about timing and load. | On-target CPU/GPU measurements, battery capacity under load, heat rejection and independent inhibit tests. |

## Transport and software boundary

Version body/world frames, SI units, timestamps, covariance, sensor rates, packet schemas and failure flags. Provide log replay and an optional local ROS 2 adapter for virtual sensor, health and command topics. A hardware transport could later implement the same interface after independent review. In this scope, all commands terminate at the virtual vehicle. No device or driver purchase, hardware-in-the-loop work, tank work, launch or sea trial is budgeted.

# D Autonomy and Verification

A route planner proposes segments. A state estimator fuses camera, sonar, inertial and depth measurements. A logically separate supervisor enforces swept clearance, localization confidence, energy and route availability before passing a candidate segment to the controller. Deterministic control and allocation generate virtual actuator commands. Evaluate bounded learned perception only after the deterministic baseline, with a holdout by scenario and an explicit abstain state.

| Scenario family | Fault or variable | Expected evidence |
|---|---|---|
| Open water baseline | Neutral buoyancy, righting, still water and current, step commands and fixed thrust. | Compare force, moment, trajectory and energy with a numerical reference and known limiting cases. |
| Navigation and perception | Darkness, turbidity, acoustic reflection, constrained visibility and localization drift. | Report coverage, pose RMSE, map RMSE and confidence behavior against synthetic truth. |
| Return and faults | Link loss, localization failure, low energy, partial propulsion failure and blocked route. | Four cases per category. Log safe return, safe hold or abort and why. Flag modeled unrecoverable cases. |
| Critical fault logic | Watchdog timeout, virtual leakage, battery cutoff and stale commands. | Verify modeled state changes and energy/inhibit logic with scripted integration tests. |
| Shipping build and learning | Performance, offline launch, tutorial and mission replay on two PCs. | Frame-time trace, packaged-build checklist, paired knowledge checks and reported sample size. |

Freeze nominal and fault seeds before scoring. Compare the two controllers on matched seeds and operating conditions. Register maps using separate synthetic controls, then score coverage and RMSE on held-out targets. Derive clearance from swept hull-to-obstacle distance, including between physics samples. Use a predeclared absolute clearance tolerance for numerical repeatability and report the worst case. Record all failures and benchmark performance on the packaged build.

A simulated return is allowed only with an observable and feasible route, sufficient virtual energy and control authority. When these conditions fail, enter a predeclared safe-hold state only if drift and clearance support it. Otherwise flag an unrecoverable abort for analysis. Avoid blind ascent beneath overhead structures. Distinguish model verification against equations from real-world validation, which would require separate physical evidence.

Test learning with a short paired quiz on non-contact mapping, link loss, uncertain localization, return energy and the difference between simulation results and real deployment evidence. Report individual and aggregate score changes without personal identifiers. Treat a small sample as formative evidence.

# E Cash Budget and Release

| Cost category | Budget | Assumption |
|---|---|---|
| Development workstation or upgrade | $1,450 | Desktop compute only. Use existing equipment if it meets the target and hold unused funds. |
| Commercially cleared environment and UI assets | $550 | Use original or cleared assets. Retain receipts, licenses and attribution. |
| Audio and accessibility assets | $350 | Licensed audio, captions and readability support. |
| C++ and Unreal engineering review | $1,200 | Time-boxed specialist review for dynamics and packaging. Obtain a fixed scope. |
| Marine and educational review | $750 | Time-boxed specialist and content checks. No implied institutional commitments. |
| Playtest and QA | $300 | Small formative cohort and second-PC test access. |
| Storage and bounded compute services | $250 | Local backups first. Optional GPU comparison only within this line. |
| Store registration allowance | $100 | Steam Direct reference fee per app. [9] |
| Release and outreach materials | $250 | Trailer, screenshots and classroom or museum outreach material. |
| Contingency | $1,000 | Includes shipping and taxes where applicable. Spend only with scope review. |
| Total cash | $6,200 | $800 below the $7,000 ceiling. Contributed applicant labor is valued separately from cash. |

## Budget and release controls

All cash obligations count toward the ceiling. Track committed and actual costs before each purchase. If costs rise, drop optional NVIDIA comparisons, purchased effects or extra assets first. Keep the core marine model, offline build and verification. Optional work requires remaining funds and time.

Check applicable Epic terms, game release notification, marketplace or third-party asset rights, dependencies, trademarks, distribution terms and third-party notices before any sale. The model assumes no Epic royalty expense at the planned scale under the standard threshold, subject to the applicable EULA and product terms. The April milestone is a release candidate and evidence package. Public sales depend on store review, acceptance and rights clearance. [8–9]

# F Unreal and NVIDIA References

[1] David Blubaugh, “Unveiling the Titanic’s Secrets: An AUV Mission to Explore the Depths,” Ocean Robotics Planet, issue 36, pp. 43–46. The supplied extract documents bow and spherical vehicle concepts, 20-inch size, eight thrusters, candidate computing and sensors, and optical communication. These are concept inputs.

[2] Supplied TeraOpenScience template, project post 11758 and prior proposal. These supply challenge prompts, schedule, concept history and engineering questions. This revision moves implementation and verification into software.

[3] Epic Games  Physics in Unreal Engine • Chaos rigid bodies and collision.

[4] Epic Games  Physics Sub Stepping • Substep configuration and callbacks. Verify on the pinned version.

[5] Epic Games  Water Buoyancy Component • Surface flotation component. The submerged AUV uses explicit marine loads.

[6] Epic Games  Niagara Overview • Presentation effects.

[7] Epic Games  Enhanced Input • Control mappings and contexts.

[8] Epic Games  Packaging Your Project • Windows executable build and distribution.

[8a] Epic Games  Unreal Engine Licensing • Commercial license, royalties and release notification.

[9] Valve  Steam Direct Fee • Public store fee reference.

[10] Fossen  Marine Craft Model • Six-degree-of-freedom equations, current-relative dynamics and damping.

[11] BYU FROST Lab  HoloOcean • UE5 underwater research simulator.

[11a] BYU  HoloOcean Fossen Dynamics • Fossen model integration example.

[11b] BYU  HoloOcean Development Guide • This documented branch uses UE 5.3. Match branch and engine before experimentation.

[12] NVIDIA  Isaac Sim • Separate robotics simulation, sensor and synthetic-data platform.

[13] NVIDIA  Isaac Lab • Optional robot-policy and learning workflow.

[14] NVIDIA  Isaac Sim Requirements • Check version, host and GPU before committing compute spend.

[15] NVIDIA  Isaac Sim ROS 2 Setup • Optional cross-tool data exchange.

[16] NVIDIA  Jetson Getting Started • Future embedded compute reference.

# G Underwater References and Transfer

## NVIDIA based underwater projects

[17] MarineGym_Underwater Robotics Reinforcement Learning • Research platform using an Isaac Sim hydrodynamics plugin. Use the paper as a benchmark reference.

[18] GRAAL Lab_IsaacSim Underwater • Independent Isaac Sim 5.1 research implementation with six-degree-of-freedom underwater dynamics.

[18a] Lighthill_Isaac Lab Hydrodynamics • Community package for GPU-vectorized hydrodynamics. Optional research example.

[18b] Isaac Underwater Examples • Community experiments. Treat as exploratory code.

The NVIDIA products and underwater examples play different roles. Isaac Sim and Isaac Lab are general robotics tools. MarineGym, GRAAL Lab and community examples add underwater behavior. The proposal uses them to inform a small cross-check or synthetic-data study only when versions, licenses and compute fit. PhysX or another general-purpose rigid-body backend does not by itself supply the marine coefficients.

## Robotics hardware and conservation references

[19] Blue Robotics_Technical Reference • Propulsion, electrical and integration reference data.

[20] Blue Robotics_Ping360 Imaging Sonar • Imaging sonar example for update and range modeling.

[21] Water Linked_DVL A50 • Beam and bottom-tracking reference.

[22] Stonefish Marine Robotics Simulator • Marine hydrodynamics and sensing comparison.

[22a] Project DAVE • Additional underwater robotics simulator comparison.

[23] NOAA_RMS Titanic Guidelines • Preservation and site stewardship.

[24] Kaushal and Kaddoum_Underwater Optical Wireless Communication • Optical propagation and communications background.

## Evidence for a future vehicle program

Export requirements, source-tagged parameter ranges, mission scenarios, observed failure conditions and an open verification register. Identify future work on pressure boundaries and penetrators, hydrostatic trim and hydrodynamic characterization, real sensor and link measurements, onboard timing and battery reserve, recovery drills, permits and archaeological review. A real Titanic mission would need independent readiness evidence and a conservation-led exterior-first approach. NOAA guidance advises avoiding entry into hull sections. [23]

# H Initial Digital Test Inputs

These planning values are an initial virtual configuration for scoring. Store each with units, reference or derivation, valid range and uncertainty. Tune against numerical benchmarks and use alternate configurations to show where conclusions change.

| Input | Starter configuration and evidence |
|---|---|
| Geometry and motion | Use a nominal 4 m fictional corridor with a 1 m square straight opening, a widened turn and one overhead obstruction. Start at ≤0.15 m/s. Compute clearance from the guarded hull, full swept path and an uncertainty allowance. Test an exterior-only survey as the minimum-risk reference. |
| Virtual endurance | Carry forward a 150 Wh nameplate, 120 Wh usable assumption and 120 W average load case as initial model inputs. At 30 minutes this uses 60 Wh. Reserve at least 36 Wh at a nominal return, with 24 Wh modeled contingency in this example. Update return energy with current, load and fault state. |
| Imaging and communications | Sweep water attenuation, pose error and glare. For local optical transfer, start with 0.5, 1 and 2 m cases and vary misalignment and occlusion. Model acoustic messaging separately. Record throughput and latency as simulated outputs. The relay stages near the entrance and there is no modeled direct optical path to the surface. |
| Frames and telemetry | Document Unreal engine frames and conversions to SI body/world frames. Export simulation clock, pose estimate, covariance, sonar and camera metadata, thruster commands, health flags, route and abort events. Keep scoring truth in a separate stream. Verify conversions, time order and missing-data behavior. |
| Pressure and fluid assumptions | Keep depth as a pressure/sensor scenario parameter and include a sensitivity range for density, current, damping, buoyancy and added mass. Structural collapse, multipath and sediment transport are represented only at the level justified by the model and documented as gaps. |
| Mapping and confidence | Score target coverage, registered map error, localization drift, contact and intervention. In repeat surveys, compare changes only after registration and uncertainty accounting. |

These inputs preserve the vehicle, propulsion, sensing, compute, link, recovery and mission-design questions from the public post. The resulting dossier identifies which claims can be checked in software and which depend on future hardware, facility measurements or approvals.

TITANIC MICRO AUV SIMULATION

# Supplemental Information for the Jury

## Ocean Robotics Planet Magazine Article

The following article is provided for jurors who require additional in-depth information.



View of the bow of the RMS Titanic photographed in June 2004 by the ROV Hercules during an expedition returning to the shipwreck of the Titanic. (Courtesy of NOAA/IFE/URI)

# UNVEILING THE TITANIC'S SECRETS

# AN AUV MISSION TO EXPLORE THE DEPTHS

By David Blubaugh and Evaluated by Walter Van Der Heiden and Dr. Michael Findler

**In the depths of the Atlantic Ocean lies the enduring mystery of the RMS Titanic, a symbol of human innovation and tragedy. Now, a groundbreaking AUV is set to embark on a daring mission, unveiling the untold stories of history's most iconic shipwreck. Join us on this captivating journey as we explore the key components and advanced technology behind the vessel that will navigate the treacherous waters and bring to light new insights into the Titanic's final resting place.**

## UNLEASHING THE AUTONOMOUS PIONEER: WHY A COMPLETELY AUTONOMOUS VESSEL REIGNS SUPREME IN TITANIC EXPLORATION

In the quest to unveil the Titanic's mysteries, the choice of technology is crucial. Meet the contenders: the AUV and the tethered ROV. While both have merits, the AUV stands tall as the unrivaled champion in exploring the Titanic's innards. Unlike the tethered ROV, the AUV operates independently, roaming freely and nimbly through tight spaces and once inaccessible and unexplored areas inside Titanic's remains. Unfettered by cables, it honors the spirit of adventure. Empowered by advanced algorithms, the AUV acts as an independent cognitive super explorer, making intelligent decisions in situ.



A CAD model of the front bow section of the RMS Titanic. This will simulate, train, validate, and verify the AUV's Cognitive Deep Learning controller to explore the inner structures of the RMS Titanic.

## ROS-2: THE OPERATING SYSTEM THAT POWERS THE EXPLORATION SYMPHONY

At the heart of the AUV's intelligence lies the Robot Operating System 2 (ROS-2), a powerful and flexible framework that orchestrates the vehicle's actions. Developed as an open-source platform, ROS-2 is a continuation of the original ROS, which has revolutionized the field of robotics with its modular and collaborative approach.

ROS-2's modularity allows seamless integration of various software components, sensors, and algorithms, creating a holistic view of the underwater environment. The AUV is equipped with an array of sensors, including high-definition cameras, sonar, lidar, and pressure sensors, providing real-time perceptions of the deep-sea landscape. The data from these sensors are processed and fused within the ROS-2 framework, generating a comprehensive and real-time internal view of the Titanic wreckage site.

ROS-2's flexibility facilitates the integration of intelligent algorithms that empower the AUV to make informed and autonomous decisions. From basic control algorithms for navigation and propulsion to advanced machine learning and cognitive deep learning algorithms for perception and decision-making, ROS-2 can accommodate a wide range of intelligent functionalities.

ROS-2's robustness and reliability also ensure that the AUV's operations can be efficiently managed and monitored remotely by operators on the surface. The framework's communication infrastructure allows for real-time data exchange, enabling operators to assess the AUV's status, review sensor data, and make decisions without direct physical intervention.

A crucial aspect of ROS-2's success lies in its vibrant and collaborative community of researchers, developers, and robotics enthusiasts. This community-driven approach fosters continuous improvement and innovation in the framework, ensuring that the AUV can leverage cutting-edge developments in robotics and artificial intelligence.

## COMPUTING POWER: RASPBERRY PI 4 AND THE NVIDIA JETSON

To serve as the Full Authority Digital Electronic Computer (FADEC) for the AUV, two promising options are being considered and evaluated: the Raspberry Pi 4 and the Nvidia Jetson computer module. Both platforms boast impressive processing capabilities, enabling real-time data analysis, decision-making, and navigation. The Raspberry Pi 4 is a widely acclaimed single-board computer known for its versatility and energy efficiency. Despite its compact size, it packs considerable computational power, making it an attractive option for resource-constrained devices like the AUV. The Nvidia Jetson computer module family is designed for edge computing applications that require high-performance graphics processing and AI capabilities. Equipped with powerful Nvidia GPUs, the Jetson modules enable accelerated computing for machine learning and deep learning tasks.

## COGNITIVE DEEP LEARNING CONTROLLER: GUIDING THE AUV'S EXPLORATION

At the heart of the AUV's intelligence is the cognitive deep learning controller, a sophisticated system that guides the vehicle's exploration through a combination of past experiences and real-time data. This cognitive controller operates in tandem with ROS-2, providing a higher-level decision-making process that enables the AUV to adapt to the dynamic and unpredictable underwater environment.

The cognitive controller is trained using advanced machine learning algorithms on vast datasets containing sensor readings, navigation trajectories, and responses to different environmental conditions. By learning from this historical data, the controller gains insights into effective exploration strategies, obstacle avoidance, and artifact identification.

## SPHERICAL SHAPE CONSTRUCTION: DESIGNING FOR STRUCTURAL INTEGRITY AND OMNIDIRECTIONAL MOVEMENT

The AUV's spherical shape offers structural advantages, ensuring robustness, buoyancy, stability, and maneuverability. The innovative design of the AUV's spherical hull enhances its ability to withstand harsh underwater conditions, including the immense pressure and unpredictable currents of the deep sea. The AUV's eight thrusters grant precise control and movement, enabling exploration of tight spaces and reaching areas previously unseen since the sinking. This exceptional maneuverability allows the AUV to navigate and travel deep through the intricate interiors of the Titanic wreckage, capturing high-resolution images and collecting critical data from hard-to-reach locations. The following figures (Figures 2a-2d) are related to the preliminary 3D CAD design of this novel AUV development.

## THE QUEST FOR COMPACT AND UNTETHERED AUVS

We must consider that Titanic's current state of deteriorated corridors and rooms, eroded by time and the ocean, poses a unique challenge for AUVs. Navigating these confined spaces demands a solution: compact Autonomous Underwater Vehicles (micro-AUVs) with a diameter not exceeding 20 inches (50.8 centimeters).

The Titanic's passageways, now narrow and collapsed, thwart larger autonomous vehicles. The 20-inch limit compels engineers to reimagine AUV design. Miniaturized sensors, thrusters, navigation systems, and small CPUs (Raspberry Pi) become vital in negotiating Titanic's treacherous corridors. This size constraint fuels innovation in power management, communication, and data processing, all housed within the AUV's limited shell.

## EXPLORING TITANIC'S DEPTHS WITH MICRO AUVS AND ADVANCED COMMUNICATIONS

Discovering the enigmas within the RMS Titanic's interior takes a leap into the future with micro-autonomous underwater vehicles (AUVs) and cutting-edge communication. These miniature explorers navigate the ship's intricate passages, capturing unprecedented images and artifacts. Fueling this endeavor is underwater wireless optical communication (UWOC), revolutionizing how AUVs transmit real-time data from Titanic's depths. Micro-LEDs enable high-speed data transfer, empowering human controllers aboard research vessels to monitor operations instantaneously. Overcoming challenges of deep-sea navigation and communication, this synergy of micro AUVs and UWOC redefines underwater exploration. Titanic's submerged stories, once confined to history, come alive as technology dives into uncharted waters, merging the past and future in a remarkable odyssey.

## MISSION PLANNING FOR EXPLORING THE TITANIC SHIPWRECK

Planning an AUV mission to explore the internal structures and layout of the RMS Titanic shipwreck would require meticulous preparation and coordination. Here's a short step-by-step outline of how such a mission might be planned:

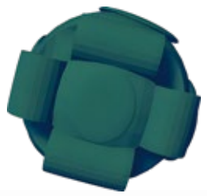
The mission planning team would conduct extensive research on historical records, previous exploration findings, and data from previous expeditions to the Titanic wreckage site. They would then analyze the available data to identify potential areas of interest, predicted dangers, and target locations for exploration.



Camera in the center



Lidar/Proximity Sensor



Proximity Sensor



Maintenance Access Hatch

Based on the research, the team would then select the appropriate sensors and algorithms to be integrated into the AUV. High-definition cameras, sonar, lidar, and pressure sensors would be crucial for generating a comprehensive real-time view of the wreckage site. The cognitive deep learning controller would facilitate intelligent decision-making during the mission.

Next, the team would define specific objectives for the mission, such as mapping the internal layout of the ship, identifying historically significant artifacts, and documenting the condition of the wreck. The AUV's parameters, including depth limits, exploration range, and areas of focus, would be set based on the mission objectives and constraints of the AUV's capabilities.

Before the actual mission, the AUV and its systems would undergo rigorous testing to ensure optimal performance and reliability. When everything else is ready, the AUV would be deployed to the Titanic wreckage site, either from a surface vessel or an underwater station, depending on the weather or ocean currents.

The AUV's remote operation and monitoring capabilities would allow human operators on the surface to monitor its progress, review sensor data, and make real-time decisions based on the information received. The AUV would navigate through the internal wreckage site using its eight orthogonally placed thrusters and spherical shape construction, enabling precise control and movement in any direction. It would explore tight spaces and reach areas previously unseen since the sinking.

The cognitive deep learning controller, equipped with advanced machine learning algorithms, would analyze sensor data to identify historically significant artifacts: parts of the ship's structure; personal belongings of passengers; or other items of historical importance. Throughout the mission, the AUV would document its findings with high-resolution images and data. After the mission, the collected data would be further analyzed and interpreted by experts to gain deeper insights into the Titanic's internal layout and historical significance.

## ENHANCING SAFETY THROUGH AUVS AFTER THE TITAN SUBMERSIBLE DISASTER

In the aftermath of the OceanGate Titan submersible disaster, AUVs have been highlighted as a safer alternative for human explorers in deep-sea missions. AUVs eliminate the need for direct human presence in treacherous underwater environments. With their advanced sensor systems and algorithmic intelligence, they can navigate hazardous conditions and respond dynamically to changing circumstances that will occur inside the Titanic's remains. These capabilities ensure that AUVs adapt to avoid potential dangers more efficiently than tethered ROVs being controlled by manned submersibles operating on the exterior of the Titanic's shipwreck. By deploying AUVs for future missions, we can enhance safety while still uncovering the mysteries of the deep ocean with this cutting-edge technology.

## UNVEILING THE TITANIC'S SECRETS: AN AUV MISSION TO EXPLORE THE DEPTHS



The exploration of the internal structures and layout of the Titanic shipwreck holds the potential for extraordinary discoveries. For example, the AUV could come across passengers' items, such as jewelry, clothing, letters, or luggage, providing a poignant connection to the individuals who were onboard during the ship's journey.

Exploring the internal spaces, the AUV might also capture images of the ship's luxurious interiors. This includes the grand staircase remains, staterooms, and dining areas, offering glimpses of the opulence and design of the early 20th-century ocean liners. Discoveries in the engine room could shed light on the engineering marvels of the Titanic, showcasing the massive engines and machinery that powered the ship.

Furthermore, the AUV could uncover previously unseen structural details of the ship's wreckage, helping researchers understand the sequence of events leading to the ship's breakup and sinking. There are also stories of valuable items, including precious gems and artwork, that were rumored to be on board the Titanic. The AUV might well stumble upon long-lost treasures submerged for over a century. Examples of lost treasures discovered by this AUV could include the following (Figures 3a-3c):

Figure 3a: La Circassienne au Bain, also known as Une Baigneuse, was a large Neoclassical oil painting from 1814 by Merry-Joseph Blondel depicting a life-sized young naked Circassian woman bathing in an idealized setting from classical antiquity. Figure 3b: Pocket watch retrieved from an unknown victim of the disaster. It had stopped at 02:28, a few minutes before the Titanic finally sank into the North Atlantic Ocean. Figure 3c: A collection of gold rings, sapphire rings, and diamond rings of many different eloquent designs that were retrieved from the Titanic shipwreck site.

### OUR EXCITEMENT OF THE AUV EXPLORATION OF TITANIC:

Setting out on our exploration of the unexplored and deep interior of the Titanic using AUVs fills us with a sense of excitement and anticipation. The Titanic, a symbol of human innovation and tragedy, holds untold stories and historical secrets within its chambers. With advanced sensor technologies, cognitive capabilities, and precise maneuverability, these AUVs will embark on a daring journey, bringing the Titanic's enigmatic past to light.

The AUV embarks on its mission to explore the Titanic's final resting place, honoring the memory of those who perished and deepening our understanding of history. With cutting-edge technology and human ambition, this extraordinary mission illuminates the lost world of the Titanic, rewriting its narrative with each artifact it uncovers. We feel wonder and admiration for these intrepid explorers bridging the gap between past and present. The Titanic's secrets emerge from the depths. Join the thrilling odyssey of exploration, embracing the unknown and celebrating human ingenuity, as we uncover the untold and forgotten stories of the Titanic.


### AUTHOR: DAVID ALLEN BLUBAUGH

Meet David Allen Blubaugh, a visionary electrical engineer on a mission to uncover the mysteries of the deep sea. Holding a Bachelor's and Master's degree in Electrical Engineering from Wright State University, Blubaugh's insatiable curiosity drives him to explore uncharted waters both in academia and the ocean's abyss.

Blubaugh's passion finds its pinnacle in micro autonomous underwater vehicles (AUVs), where he leads a groundbreaking effort to unveil the RMS Titanic's hidden interior. Using cutting-edge technology and engineering expertise, he aims to bring history to light.

A true advocate for progress, Blubaugh is championing Kickstarter and Patreon campaigns to unite enthusiasts, scientists, and history buffs in advancing micro AUVs. Through these platforms, he seeks to expand the boundaries of ocean exploration.

For those inspired to join his mission, David Blubaugh can be contacted at davidblubaugh2000@yahoo.com or reached via text at 1-937-304-7952.

Blubaugh's reach extends beyond the sea. He is the author of the acclaimed book "Intelligent Autonomous Drones by Cognitive Deep Learning," delving into the integration of robotic rovers in Egypt's catacombs, weaving technological advancement with historical significance.

